



RAM provides sales, service, training and turn-key remediation services using MuniRem® products to neutralize explosives.

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CASE STUDIES

MUNIREM TECHNOLOGY

**Safe and
Cost-Effective
Neutralization and
Remediation of
Explosives and
other Energetics**

www.munirem.com

- 1** Safe removal of H-6 explosives and on-site neutralization using MuniRem
- 2** Neutralization of aged TNT in pipe using aqueous solution of MuniRem
- 3** Dissolution and neutralization of nitrocellulose (“NC”) propellant in MuniRem
- 4** Neutralization of bulk chemical warfare materiel (sulfur mustard)
- 5** Neutralization of reclaimed and stockpiled Explosive D (picric acid-based explosives) by MuniRem
- 6** Decontamination of explosives contaminated equipment and building walls by MuniRem
- 7** Breaching and Inerting of recovered scuttled Confederate States Ship (CSS) Georgia underwater munitions by MuniRem
- 8** Application of MuniRem as a solution for the management of energetics in indoor training ranges
- 9** Decontamination of commercial explosives manufacturing equipment and buildings using MuniRem solution
- 10** Application of MuniRem to decontaminate explosives contaminated equipment and building at an active ammunition production plant
- 11** Decontamination of explosives on multiple media (Building, Equipment, Soil, Sludge, Wastewater, Bomb Casings) at a demilitarization site (Part A)
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- 13** MuniRem application provides safe access for Army EOD Tech operations
- 14** Remediation of explosives in soil
- 15** In-situ bioremediation of perchlorate and explosives in soil.

Company background

MuniRem Environmental was founded by Dr. Valentine Nzungu with the mission of providing a better solution for the remediation of water, soil, buildings and equipment that are contaminated with explosives residues than those in general use. MuniRem Reagent, our main product, uses reduction chemistry to completely destroys explosives safely and quickly. We take special delight in the projects we have worked on that involved restoring contaminated sites to nature or public use.

We provide product and services to US Fortune 100 companies, governmental, military and environmental organizations. Our products are used by leading environmental engineering firms throughout the world, by specialized demilitarization facilities and by explosives manufacturers as part of their maintenance and safety processes. In the United States, our technology is recognized to be effective by the United States Army Corps of Engineers and has been specified by them for numerous projects. It was recently recognized by the National Academy of Science, Engineering and Medicine to be an effective alternative to Open Burn/Open Detonation for the destruction of munitions.

Our Products

MuniRem Reagents have been proven in laboratory tests, field trials and completed projects to be effective for the destruction of the following energetics/contaminants.

- Ammonium Nitrate
- Black Powder
- DNTs
- H-6
- HMX
- Lead Azide
- Lead Nitrate
- Lead Styphnate
- M6/CBI
- Magnesium Styphnate
- Nitrocellulose propellant
- Nitroglycerin
- Nitromethane
- Organic peroxides
- PETN
- Picrate
- Picric Acid
- Pyrotechnics
- RDX
- Tetrazene
- TNB
- TNR
- TNT
- OBOD ash
- Explosives in pink water
- Explosives in spent activated carbon

MuniRem Reagent comes in a variety of formulations and its application is tailored to each site to ensure optimum performance and desired results. It can be applied as a solid or aqueous solution.

Contaminated soils treatment involves mixing MuniRem powder into the soils and adding water to achieve in-situ or ex-situ remediation.



MuniRem UXO technician sprays MuniRem Solution on aged dynamite, weeping Nitroglycerin to render it safe to handle.

Groundwater remediation involves injection of the MuniRem solution into the site groundwater to instantly degrade the dissolved contaminants and create permeable reactive aquifer solids for long-term treatment of the plume.

Decontamination applications involve spraying MuniRem solution on building walls, large equipment and scrap metals (including bombs shells, bomb components, projectiles); and soaking small sized equipment in baths of MuniRem solution.

MuniRem Reagent is one of the recognized alternatives to Open Burn/Open Detonation which involves application of MuniRem in solution or powder form to neutralize bulk explosives and destroy residual explosives in different materials.

On most of our recent projects, decontaminated material certified to MDAS (5X) standard is required and this has been achieved rapidly and effectively by spraying or soaking material in MuniRem Reagent solution. The wastewater in each case has been independently tested and verified to be non-hazardous.

Using MuniRem Reagent

Prior to using MuniRem Reagent, staff have to complete MuniRem Safe Handling and Application Training. MuniRem Reagent can be purchased directly from MuniRem Environmental, LLC and we also carry out projects for a variety of customers both as a prime and a subcontractor using our team of UXO/EOD technicians. MuniRem Reagent can also be purchased from our partners in the USA and Israel and many environmental engineering and demilitarization contractors are trained in the use of MuniRem Reagent and can perform projects using it.



Safe removal of H-6 Explosives from equipment and onsite neutralization by MuniRem

Situation

H-6 (1.1D) explosives contamination was present in bulk and residual form on a Melter/Flaker machine within a building. After review of multiple solutions, the client specified the use of MuniRem Reagent for safe recovery and neutralization of the bulk explosives from the equipment. The photos below show the recovered H-6 (some chunks were 13" long) and processing with MuniRem.

Solution

Initial spray application of MuniRem solution was used to desensitize smaller pieces of the H-6 explosives instantly, enabling for safe ingress/egress for intensive recovery of large H-6 chunks. Under a continuous spray of MuniRem solution, the staff removed and transported manageable small batches of H-6 bulk material from hopper and tray assemblies to the nearby process area. This explosive material was then neutralized in reaction tanks. Solid and liquid generated waste products were tested for explosives and stored for subsequent transport as nonhazardous material.

Result

The project team safely removed hundreds of pounds of bulk explosives from the Melter/Flaker machine. Although the project plan was based on the assumption that approximately 200 lbs of H-6 was left on the Melter/Flaker unit, over 900 lbs of bulk explosive material was eventually recovered; including over 950 lbs of solids (sludge and sediment). Recovery and neutralization of the bulk H-6 enabled dismantling the Melter/Flaker machine, support structures, conveyor assembly, fume hood, ducts and wooden platform with hand tools. The equipment was decontaminated to 5X to enable for off-site recycling using the MuniRem solution alone. The generated wastewater was characterized and determined to be non-hazardous; achieving regulatory level compliance in the final disposition of waste streams (liquids and solids) for characteristics of ignitability, corrosivity, reactivity, explosivity, and toxicity.

The project team successfully adapted MuniRem application practices to overcome inclement weather conditions that were unusual for the Camp Minden region; two days of snow, freezing rain, and multiple days with temperatures below freezing.

Engagement details

Client

Confidential Private Industry Client

Site

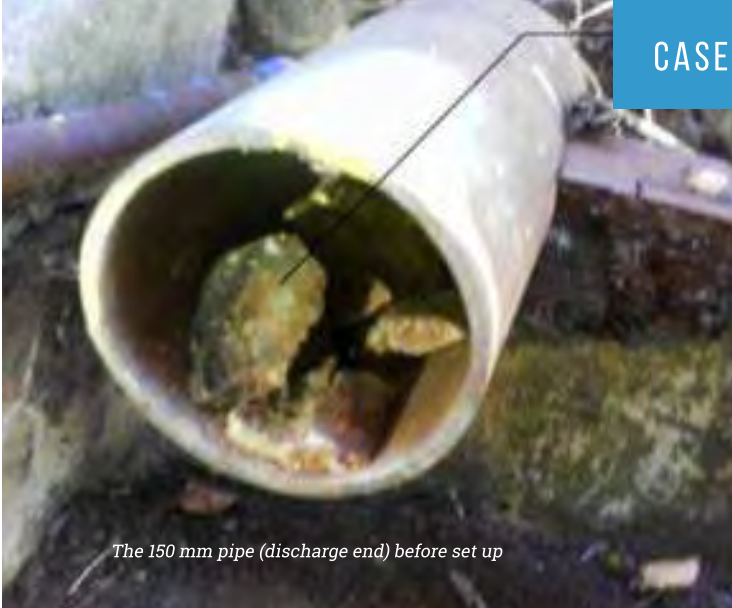
Explo Systems, Inc. Site.
Former Louisiana Army Ammunition Plant, Camp Minden, Louisiana

Task

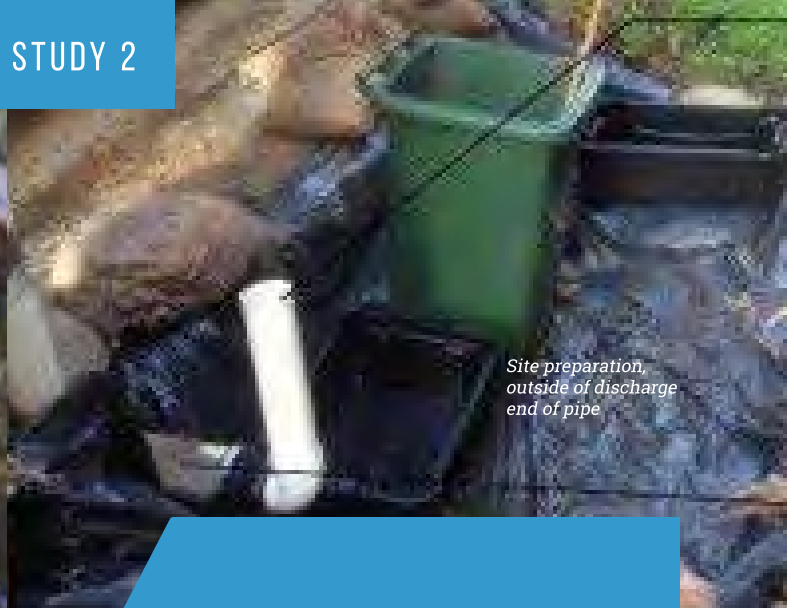
Safe Recovery of H-6 Explosives from Equipment and On-site Neutralization

Date

February 2015



The 150 mm pipe (discharge end) before set up



Site preparation, outside of discharge end of pipe

Neutralization of Aged TNT at Former Munitions Plant

Situation

CH2M HILL was contracted by the Australian Department of Defence to perform an investigation and assessment of residual explosives capable of creating a personnel hazard within select buildings and utilities. CH2M HILL's investigation identified approximately 12 kilograms (kgs) of aged TNT in a 150 millimetre (mm) diameter, 2.6 meter (m) pipe beneath the northwest corner of one of the site buildings. CH2M HILL needed to immediately eliminate the explosive hazard from the pipe. The test site is a former military munitions production plant and has been encroached by urban development.

Solution

MuniRem Environmental was approached by CH2M HILL to provide MuniRem for use to remove the explosive hazard. MuniRem Environmental reviewed site assessment data and photos provided by CH2M HILL's UXO personnel. MuniRem Environmental custom formulated MuniRem reagent and shipped to the project site. An exclusion arc of 500 meters was set-up around the worksite. CH2M HILL and MuniRem Environmental personnel prepared MuniRem solution and used to flush the pipe. After many flushes, the discharge end of the pipe was capped, and MuniRem poured into the pipe from inside the building, allowing it to pool up inside the pipe, keeping it in contact with the residual explosives. Once the pipe was filled with MuniRem, it was left alone for 18 hours. The next day the MuniRem solution was removed and the pipe was flushed a few more times. A camera was inserted into the pipe to confirm complete destruction of the TNT chunks. All of the flushing MuniRem solution was collected in three 220 liter drums. Residual explosives in the wastewater was treated by adding MuniRem powder to the wastewater.

Result

Visual and videos obtained by the camera inserted into the pipe confirmed that MuniRem achieved the cleanup goal in the <48 hrs after application, which was reconfirmed by Analytical Laboratory analysis for explosives and MuniRem degradation products. MuniRem was effective in the neutralization of the aged TNT that had accumulated inside the pipe for many years. The project goals were achieved without interrupting the activities of other contractors performing work on-site and the inhabitants in nearby residents.

Engagement details

Client

CH2M Hill (Prime Contractor)

Site

Australian Defence Site

Task

Neutralization of Aged TNT in Pipe Using Aqueous Solution of MuniRem

Date

May 2013

33g of NC propellant reduced to <5g of non-explosive residual in less than 48 hrs



2.4 g of NC propellant residual in less than 24 hours of treatment



Dissolution and Neutralization of Nitrocellulose Propellant

Situation

Indiana AAP extends over 10,649 acres and has been in operation since 1941. The facility produced large quantities of nitrocellulose and nitroglycerin based propellants and explosives during WWII, the Korean War, and the Vietnam War. It has been declared an excess site by the U.S. Army. The manufacturing equipment and building at Indiana AAP must first be decontaminated prior to deconstruction and transfer of land to the state of Indiana. The main challenge for decontaminating the buildings has been finding a safe and cost-effective technology to dispose of the solid NC propellants swept off the equipment and buildings.

Solution

MuniRem Environmental developed an innovative method to dissolve the different sized propellants (single, double and composite base) followed by neutralization at ambient temperature. Indiana AAP provided three sizes of double base solid NC propellant for dissolution and neutralization. The proprietary formulations were prepared to dissolve and neutralize multiple batches of the NC propellants.

Result

NC propellant pellets were dissolved and formed a dark solution. The breakdown products were sulfate and small amounts of nitrate and nitrite. The cellulose transformed to glucose and mannose primarily, with smaller amounts of arabinose and xylose. This demonstration completed at Indiana AAP confirmed that NC propellant can be neutralized and degraded to monosaccharides (sugars) that may become a potential source of raw material for cellulosic ethanol production or disposal by biodegradation.

Sample	Before Treatment	After Treatment
Nitrocellulose	Propellant grains	Non-Detectable
Sugars	N/A	Glucose, mannose, arabinose, xylose
Nitrate as N	N/A	309 mg/L
Nitrite as N	N/A	1000 mg/L
Sulfate	N/A	Non-Detectable
Total Sulfide	N/A	18.6 mg/L (lower than reporting limit)

Engagement details

Client

Department of the Army

Site

Indiana Army Ammunition Plant ("AAP"), Indiana

Task

Dissolution and Neutralization of Nitrocellulose ("NC") Propellant

Date

October 2010

Neutralization of Chemical Warfare Agent – Bulk Mustard

Situation

Sulfur mustard [bis(2-chloroethyl) sulfide] is the most prevalent chemical warfare agent present at Non-Stockpile Chemical Materiel (NSCM) Sites. Destruction of bulk (neat) sulfur mustard (HD) and remediation of HD contaminated soil and materials poses serious health and safety challenges. The main challenge for neutralizing CWA has been finding a safe and cost-effective technology to destroy the agents without forming and accumulating harmful by-products. MuniRem was evaluated as a cost-effective, safer and green alternative neutralant of the CWA mustard.

Solution

This project was a collaboration between the United States Non-Stockpile, an Army HQ office, Tennessee Valley Authority, SAIC, and MuniRem Environmental. All tests were performed at Non-Stockpile's Laboratory in Edgewood, MD. Multiple doses of bulk HD (93.7 wt% purity) were challenged with either MuniRem powder or the solution at a temperature of 50 ± 2 °C for 6 hours. Additional tests were conducted with sand and metals added as impurities to simulate MuniRem effectiveness for remediation of HD contaminated soil and empty one ton containers. The disappearance of HD during the 6 hour test and the formation of by-products was investigated.

Engagement details

Client

Non-Stockpile and Army HQ (DoD)

Site

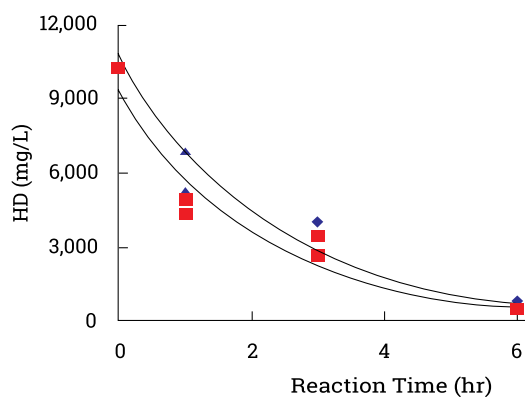
Non-Stockpile Edgewood, Maryland & Lawrence Livermore National Laboratory (LLNL)

Task

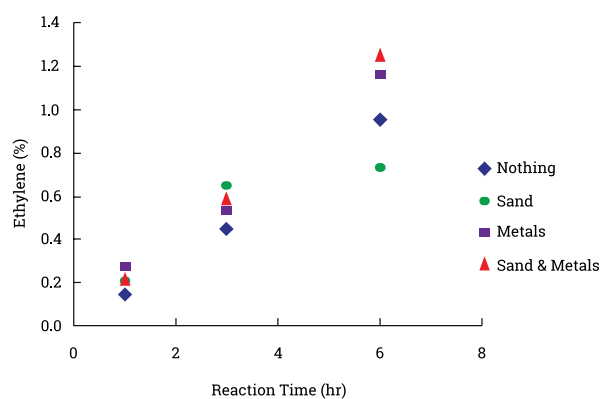
Evaluation of MuniRem for Neutralization of Bulk Sulfur Mustard

Date

February - May 2010



Rate of bulk HD destruction by MuniRem for a 6 hour test
>95% of initial bulk HD destroyed in 6 hours.



Evidence of ethylene formation as a by-product of MuniRem degradation of HD, with and without impurities.

Result

MuniRem rapidly degraded bulk (neat) mustard to chloride, sulfur and ethylene gas. The breakdown products of MuniRem reagent were sulfate and thiosulfate. No hydrogen sulfide was formed. The degradation of HD in the presence of sand and metal was more efficient than in the homogeneous samples (i.e., Nothing). This demonstration confirmed that sulfur mustard is neutralized and degraded to ethylene gas, which is known to rapidly oxidize to CO₂. Building on the lessons learned from this feasibility test and other demonstrations performed at the Lawrence Livermore National Laboratory by Ellen Raber and Raymond McGuire (2002), MuniRem Environmental has developed two products, applied in solution and gel form, for the neutralization and decontamination of CWMs and BWMs in different materials.



33g of NC propellant reduced to <5g of non-explosive residual in less than 48 hrs



Wet picric acid recovered from explosive D projectiles



Neutralization of Picric Acid-Based Bulk Explosives

Situation

The munitions item assigned to MuniRem Environmental for neutralization was a U.S. Navy projectile containing Explosive D (ammonium picrate). Explosive D is a stable, yellow-crystalline explosive once used as the standard main charge for armor-piercing bombs and projectiles. MuniRem Environmental pilot-tested the use of MuniRem for instant neutralization of wetted picric acid reclaimed from demilitarized munitions.

Solution

MuniRem Environmental designed an explosive and chemical neutralization (ECAN) reactor with a throughput of 10 pounds per hour. An optimum dose of MuniRem was prepared and used to neutralize multiple 10-pound batches of explosives in the reactor. The resulting solution was polished in a reactive column prior to disposal.

Result

The explosives were degraded to formate and nitrogen gas in less than one hour. The highest throughput for neutralization of bulk high explosives was achieved in a 100-gallon reactor. Using the optimum MuniRem dosage, the Composition D was destroyed to 2 mg/L in the ECAN reactor under an hour.

MuniRem achieved nondetectable levels (US DoD 5X) for explosives initially present on the contaminated metal casings. A protocol was developed for neutralization of bulk explosives and decontamination of metal casings with MuniRem solution.

Engagement details

Client

Department of the Army, U.S. Army Corps of Engineers

Site

ATF Approved Facility, Minnesota

Task

Neutralization of Reclaimed and Stockpiled Explosive D (picric acid-based explosives) by MuniRem

Date

November 2009



Before



After

Rapid decontamination of halved bomb casings before and after MuniRem treatment

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Equipment and building fixtures inside bay area



Decontamination of explosives contaminated equipment and building walls by MuniRem

Situation

H-6 (1.1D) explosives contamination was present in bulk and residual form on a Melter/Flaker machine within a building, as well as all fixtures within the building. After review of multiple solutions, the client specified the use of MuniRem Reagent for safe recovery and neutralization of the bulk explosives to remove the explosion hazard for safe disassembly of all equipment and decontamination of the Bay area building fixtures. The photo below shows the small footprint of MRE's decontamination set-up next to the building of interest.

Solution

An initial spray application of MuniRem solution in hallways and the Bay containing the Melter/Flaker machine neutralized H-6 contaminated surfaces and provided safe ingress/egress for staff. The sprayed MuniRem solution successfully neutralized, soaked, and cleaned loose materials in the Bay. The sprayed walls, ceiling, hood, and all equipment surfaces were rinsed after confirmation of complete explosives neutralization and destruction. Applied MuniRem solution on the floor progressively dissolved and destroyed the explosives in cracks during equipment and Bay decontamination.

Result

The project team decontaminated walls, floors, ceilings and disassembled equipment as well as achieved regulatory level compliance in the final disposition of waste streams (liquids and solids) for characteristics of ignitability, corrosivity, reactivity, explosivity, and toxicity. The equipment was decontaminated to US DoD level 5x, certified by a UXOSO/QCS. This allowed for safe dismantling and shipping off-site for recycling. According to regulatory and explosive safety qualified professionals, "the Bay work area is now the cleanest and safest place within the Building." The project team successfully adapted MuniRem application practices to overcome inclement weather conditions that were unusual for the Camp Minden region; two days of snow, freezing rain, and multiple days with temperatures below freezing.

Engagement details

Client

Confidential private industry client

Site

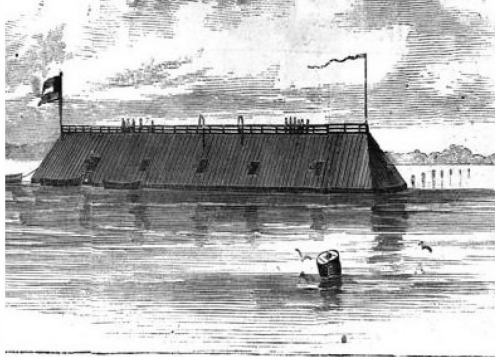
Explo Systems, Inc. Site.
Former Louisiana Army Ammunition Plant, Camp Minden, Louisiana, USA

Task

Decontamination of equipment and building

Date

Jan – Feb, 2015



The Rebel Iron-clad "Georgia."

CASE STUDY 7



Inerting of breached Dahlgreen ball



Fully inerted Brooke projectile and Dahlgreen canon ball

Breaching & Inerting of recovered scuttled Confederate States Ship (CSS) Georgia underwater munitions by MuniRem

Situation

MuniRem Environmental (MRE) was contracted through DONJON Marine Inc., to support inerting operations for munitions and explosives of concern (MEC) removed from the Confederate States Ship (CSS) Georgia in the Savannah River. MRE's scope of work was to receive, store, inert, and dispose of munitions and explosives of concern (MEC) items recovered from the CSS Georgia wreck site. These MEC items, Civil War era cannon balls, are considered to be Discarded Military Munitions (DMM).

A Navy Explosives Ordinance Disposal dive team conducted an underwater UXO clearance around the sunken wreck and raised the munitions. The two primary types of munitions items recovered were 6.4 inch Brooke projectiles and 9 inch Dahlgren Mortars. Custody of 170 munitions was transferred from the US Navy to the US Marine Corps and then to the MRE team for inerting using MuniRem - a patented technology. The MRE team was composed of a Senior UXO Marine, UXO QA and Safety Navy Senior Chief, Senior Chemist and Chemical Engineer.

Solution

A MRE process was successfully applied to remove the main charge and the threat of a detonation and fragmentation of the munitions safely without disturbing the most hazardous part of the munition (the fuze). Thereafter, the amount of explosives remaining within the projectile was contained within the fuze. Subsequently, the fuze was rendered safe by unscrewing and inerting in MuniRem solution or drilling directly through the fuze body to access and neutralize the explosives again using a solution of MuniRem. All explosive material flushed from the munitions was fully neutralized with MuniRem solution for safe disposal as non-hazardous waste.

Result

An automated remote disassembly line utilizing a combined chemically enhanced hydro mine process provides a unique safe and environmentally friendly non-thermal alternative solution for demilitarization. Custody was passed back to the USACE with the munitions now safe for shipment on public roads, certified DoD level 5x by UXOSO/QSC. The munitions will be conserved by the University of Texas and distributed to museums around the country.

Engagement details

Client

Donjon Marine as Prime for United States Army Corps of Engineers

Site

Savannah River Harbor Expansion, Savannah – Georgia, USA

Task

Inerting of recovered underwater munitions (Projectiles) on-site

Date

September – November, 2015



Indoor Range Residue (IRR)

MuniRem powder
shipped via air,
land and sea

Engagement details

Client

United States
Department of Defense

Site

Multiple Indoor Training
Ranges, USA

Task

Alternative Solution for
Cleaning Indoor Range
Propellant Residues

Date

Ongoing

Application of MuniRem as a solution for management of energetic residues in indoor training ranges

Situation

The increased used of fragile ammunition in military training ranges in order to limit lead exposure results in increased generation of residues as well as a color change in the residue. The range residue is generated in multiple indoor ranges from fired small arms ammunition made from propellants. The propellant/gun powder material in bulk form is considered a hazardous material with 1.3 classification. Interim analytical results indicate that the propellant residue collected from the floor of some indoor ranges consists of approximately 90% unburnt double base propellant. Therefore, the propellant residue may be considered as a reactive hazardous waste with a DOT classification of 1.1 to 1.3.

To enable the DoD to continue with its use of the fragile ammunition in its indoor range training exercises, a management solution for the energetic residue deposited on the range floors is desired.

Solution

The development of cleaning and management procedures for the energetic residues in the indoor ranges was preceded by bench scale tests. The tests confirmed that MuniRem is an effective reagent for the rapid neutralization and destruction of the neat propellant and the range residues. During routine range cleaning events, the MuniRem powder is sprinkled over the propellant residues then sprayed with water to stimulate a rapid energetic neutralization reaction. The residue is collected from the floor after 1 - 2 hours, placed in drums and labeled as a non-hazardous waste after confirmatory sampling. For self performing military sites and range management contractors, MuniRem Environmental (MRE) offers on-site training to the staff. The MuniRem powder is purchased from MRE and shipped to the military installation in United States Department of Transportation approved containers. MRE has developed standard operation protocols for cleaning of energetic indoor range residue on the floor and other surfaces.

Result

The MuniRem reagent is effective for cleaning energetic waste in indoor ranges. The energetics are neutralized and destroyed, while the metals are stabilized as the insoluble metal sulfides. Thus, the MuniRem cleaning procedure generates a Non-Hazardous waste. Our MuniRem solution is flexible and scalable with a "pay-as-you-go" model, requires NO material upfront costs.



CASE STUDY 9

Decontamination of commercial explosives manufacturing equipment and buildings using MuniRem solution

Situation

Manufacturers of explosives routinely clean their equipment and work areas with steam. The wastewater generated during the cleaning effort is collected and treated at on-site wastewater treatment plants. Steam cleaning is a phase transfer procedure, meaning the explosives are simply dissolved and not destroyed. When the residual water dries the explosives recrystallize and pose an explosive hazard. Steam decontamination also generate a significant amount of reactive wastewater (i.e., a hazardous waste) that must be disposed at an additional cost. The explosive contaminated wastewater may seep into cracks in the concrete and accumulate dangerously high levels of explosives over the years. The explosives manufacturing industry has an immediate need for an explosive destruction solution for routine cleaning and maintenance of their manufacturing equipment and work area. Such a solution must not generate a hazardous waste as an end product.

Solution

MuniRem is a successfully demonstrated chemical reduction technology for multiple explosives (e.g., AN, black powder, DNTs, HMX, RDX, TNT, picrate, lead styphnate, lead azide, PETN, pyrotechnics, propellants, tetrazene, trinitroresorcinol, TNB, NG), chemical warfare agents such as mustard, and for remediation of chlorinated organics and metals. The MuniRem chemical reagent employs uniquely formulated reduction chemistry to catalyze near instant neutralization of bulk explosives and rapid destruction of MC. The reagent is packaged and shipped in powder form. When the MuniRem reagent is applied to explosives and water is added, it generates free radicals that react very rapidly to completely degrade oxidized organic compounds, such as explosives and chlorinated organics into non-hazardous, nonenergetic end-products. Explosives manufacturers apply the MuniRem reagent as a powder or aqueous solution during routine cleaning and maintenance of their production facilities.

Result

Manufacturers of explosives now have MuniRem products as a decontamination and cleaning solution that is easy to use. The spray application of MuniRem liquid destroys explosive residues and generates wastewater characterized as a Non-hazardous waste. Our MuniRem solution is flexible and scalable with a "pay-as-you-go" model, requires NO material upfront costs. The ultimate benefit of our MuniRem solution is a safe work environment for explosives manufacturers and contractors repairing and renovating explosives contaminated equipment and building fixtures. The MuniRem solution is widely recognized as a solution for safe chemical neutralization of explosives and applied worldwide.

Engagement details

Client

Commercial Explosives Manufacturers

Site

Multiple in USA and International

Task

Routine maintenance of explosives manufacturing facilities

Date

Ongoing



Spraying MuniRem to decontaminate building



Demolition of the building after decontamination by MuniRem

Application of MuniRem to decontaminate explosives contaminated equipment and building at an active ammunition production plant

Situation

The 1,750-square-foot former TNR production building was slated for demolition/removal. TNR was manufactured in this structure until the 1970s, when the building was closed to further use. During the manufacturing process, TNR laden vapor permeated the building materials. The explosive vapor condensed and crystallized on the surfaces and the interior of the wood frame walls and cracks. The crystal residue was determined to be an explosive shock hazard. Because Lead Styphnate was manufactured in a neighboring building, it was included among the potential explosives of concern. Due to the building's explosive hazard risk and its proximity to other nearby active munition production buildings, the building was not a candidate for normal demolition. The ability to remove asbestos inside and out of the facility was precluded by the presence of explosives residues and the potential for explosion. Due to regulatory concern over the inability to meet safety requirements, the EPA and LCAAP commissioned an Engineering Evaluation and Cost Analysis (EE/CA) to identify a safer and cost effective solution.

Solution

Of the five technologies evaluated by the EE/CA, MuniRem was determined to be the safest and most cost-effective solution for removing the explosive hazard, so that the building demolition could be safely accomplished. The evaluation of MuniRem included a bench scale and pilot test conducted at the Army's ERDC laboratory in Vicksburg, Mississippi, USA. At the full scale, the MuniRem solution was prepared and sprayed on the building exterior and interior fixtures to achieve surface decontamination. Therefore, the asbestos contaminated materials were safely removed for disposal. The MuniRem solution was sprayed into production vessels and pipes to destroy any accumulated bulk explosive. EXPRAY and Visual Inspection were used to confirm the complete removal of the explosive hazard by MuniRem. As a result, the building fixtures and concrete foundation were safely demolished and disposed per the regulations.

Result

Concentrated MuniRem solution was sprayed on the exterior and interior of the building to destroy the bulk and residual explosives. Equipment was decontaminated to US DoD 5x level by MuniRem alone. As a result, the initially planned follow-on thermal treatment was not required. The decontamination was completed ahead of schedule and on budget; significantly below the cost of thermal decontamination. Our MuniRem solution was effective in penetrating and destroying crystallized explosives in wall cavities and cracks in the concrete floor, thus the soil remediation option task was avoided.

Engagement details

Client

United States Department of Defense

Site

Active Munitions Manufacturing Plant

Task

Removal of Explosive Hazard in Equipment and Building Fixtures

Date

Ongoing

Decontamination of Explosives on Multiple Media (Building, Equipment, Soil, Sludge, Wastewater, Bomb Casings) at a Demilitarization Site (Part A)

Engagement details

Client
Global Government Contractor

Site
Confidential Asian Pacific Island

Task
Decontamination of Composition-D (picric acid) Contaminated Building & Equipment and Dismantled Bomb Shells by MuniRem

Date
February 2012

Situation

The site is a demilitarization facility for dismantling and neutralizing old unexploded ordnance (many from WWII). Decontamination was required for (i) equipment and building involved with demilitarizing old ordnance, which are contaminated with picric acid and (ii) dismantled shells, which are lined with crystallized picric acid.

Building & Equipment

MuniRem solution is sprayed onto the equipment using a hand-held garden sprayer and is poured onto the contaminated concrete flooring to remove explosive substances.



Picric Crystals (bright yellow)

Visible picric crystals on building surfaces (in bright yellow) before treatment.



Picric Crystals Neutralization (reddish brown)

Instant color change to reddish brown signifies neutralization reaction.



MuniRem continues to breakdown the yellow picric crystals.



MuniRem-treated area is left to air-dry.



24 hours post-MuniRem

24 Hours Later Visible and significant reduction of picric crystals.



2 weeks post-MuniRem

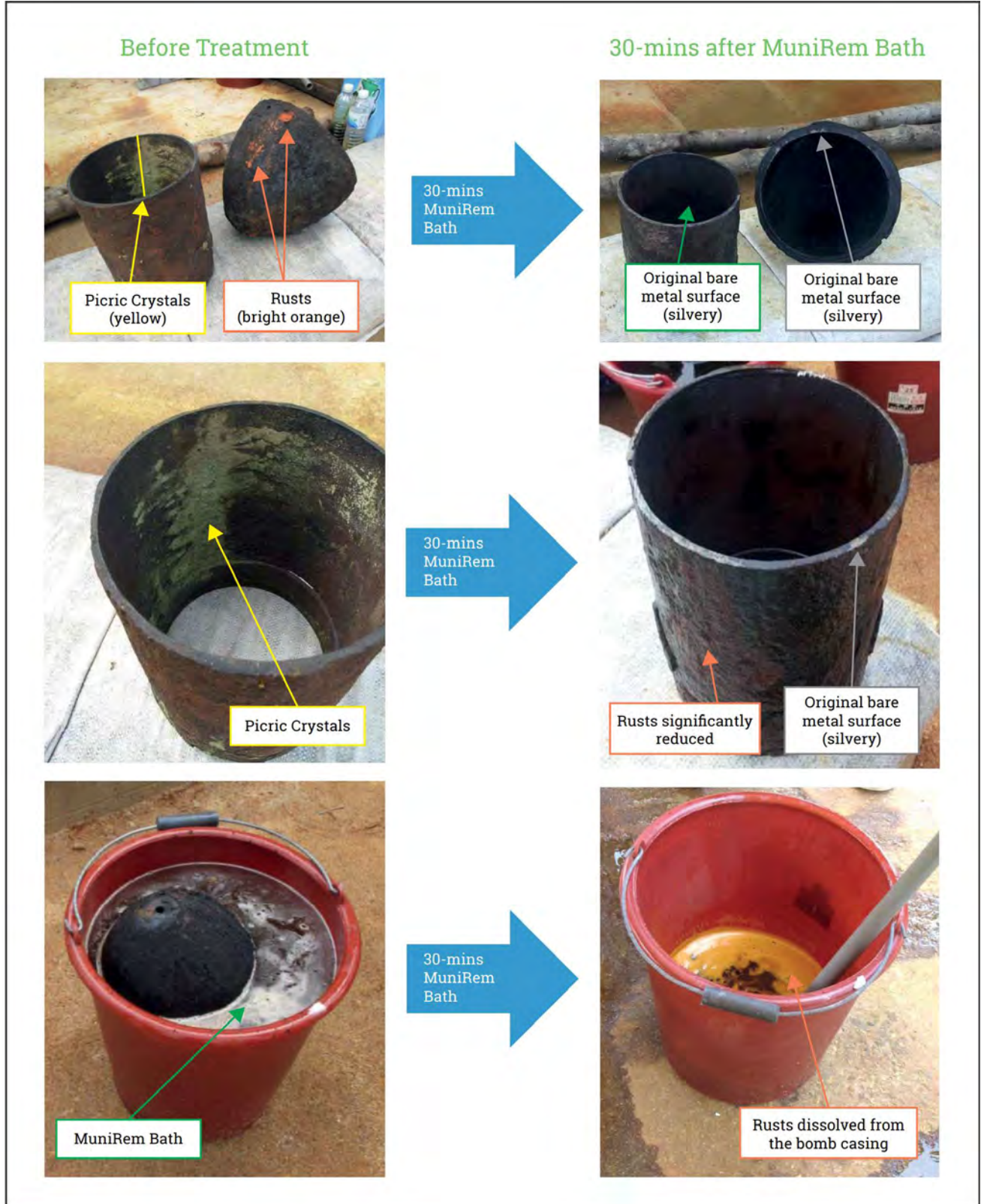
2 Weeks Later No re-crystallization of picric acid.

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Bomb Casings

The 1,750-square-foot former TNR production building was slated for demolition. The bomb casings are submerged into a MuniRem solution bath for half an hour until the explosive substances are dissolved.

Demonstration of MuniRem on the equipment, building and bomb casings was observed by over ten individuals, including representatives from the local military and government contractor.



MuniRem is a registered Trade Mark of MuniRem Environmental, LLC

Decontamination of Explosives in Multiple Media (Building, Equipment, Soil, Sludge, Wastewater, Bomb Casings) at a Demilitarization Site (Part B)

Situation

The site is a demilitarization facility for dismantling and neutralization of recovered old unexploded ordnance (many from WWII). Most of the surrounding soil and water involved in the demilitarization process was contaminated with picric acid, characterized by its bright yellow color and require remediation.



Picric acid (bright yellow)

Soil contaminated with picric acid stored in bags before MuniRem treatment

Engagement details

Client
Global Government Contractor

Site
Confidential Asian Pacific Island

Task
Decontamination of Composition-D (picric acid) Contaminated Soil, Sludge and Wastewater by MuniRem

Date
February 2012

Soil

MuniRem powder was mixed into the explosive-contaminated soil and water was added to initiate rapid degradation. The soil then immediately turned from its bright yellow shade to a deep red/brown color. This immediate reaction signified the instant neutralization of the picric acid. Within 24 hours, the dark red color significantly dissipated with natural oxidation. Two weeks after application, the treated soil regained its original color, with no trace of picric acid.



1 MuniRem mixed into contaminated soil

2 Water immediately activates the neutralization

3 24 hours after MuniRem

4 2 weeks after MuniRem

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Water

MuniRem powder is directly poured into the contaminated water and allowed to dissolve and destroy the explosive. Upon contact, the chemical reaction in the water displays a vibrant red color, distinctive of the oxidation process. The picric acid is being neutralized. After 24 hours, the color fades into lighter brown. After two weeks, the vibrant red color has dissolved.



Result

MuniRem achieved instantaneous degradation of the various picrate-contaminated media immediately after being activated by water. The bright yellow color characteristic of the picric acid instantly turned red, signifying oxidation and hence, the success of the neutralization reaction.

The efficacy of the treatment for both the soil and water sites was also monitored 24 hours and two weeks post-treatment. In both cases, the yellow and red colors had disappeared, revealing the soil's original color and clearer waters. Following MuniRem treatment, levels of picric acid dropped considerably.

Demonstration of MuniRem was observed by over ten individuals, including representatives from the local military and government contractor.



Lake on demilitarization site, contaminated with picric acid and requiring remediation

MuniRem Application Provides Safe Access for Army EOD Tech Operations

Situation

Following an explosion in a storage magazine used to store Clean Burning Igniter (CBI) at Camp Minden, Louisiana, a decision was made by the Louisiana Military Department (LMD) and the United States Department of the Army to quickly dispose of the remaining CBI in two other magazines on base. The remaining two magazines held 200,000 pounds of CBI, along with 40,000 pounds of M6 propellant. The approved method of disposal was by initiating a controlled burn. In order to initiate the controlled burn safely, the explosive risks presented by any potential residual explosive accumulations by the magazine door, cavities and floor needed to be removed. Removing the explosive risks in the door cavities and entrance into the magazine would allow for the doors to be opened safely.

The Explosive Ordnance Disposal personnel from the Army's 797th Ordnance Company and 79th Ordnance Battalion from Fort Hood, Texas, was assigned the mission to execute the controlled burn of the explosives. MuniRem Environmental was contracted by the LMD to apply its MuniRem solution on the magazine doors and floors to create safe passage for the EOD team to perform the controlled burn.

Solution

After a thorough review of the chemistry of decomposing unstable nitrocellulose (CBI) a customized formulation of MuniRem was developed, prepared and shipped to the site in powder form. The MuniRem powder was dissolved in water to prepare a concentrated (i.e., high strength) MuniRem solution that was sprayed to the magazine doors. The application of the MuniRem solution to each magazine door and floor was performed at least eight hours before the EOD team remotely opened the door.

Result

The MuniRem treatment was effective in eliminating the explosive risk in the door surfaces, cavities, magazine entrance and floor. The applied MuniRem stabilized the CBI and also neutralized and destroyed any picric acid formed when the stabilizing compound in nitrocellulose (diphenylamine) decomposes. A visible color change and fizzing was observed when the MuniRem solution contacted the surfaces, confirming the presence of explosives undergoing neutralization. The EOD Techs remotely opened the magazine doors without an unintended detonation and ignited the CBI. The success of this and other projects have confirmed the efficacy of our MuniRem solution in removing explosive risks in support of EOD tasks.

Engagement details

Client

Louisiana Military
Department

Site

Camp Minden, Louisiana,
USA

Task

Stabilization of Highly
Unstable Clean Burning
Igniter (CBI) by MuniRem

Date

October 2016

Remediation of Explosives in Soil

Situation

The test site is an inactive and unoccupied government-owned Operations Support Command site that was previously active from 1941 to 1992. The selected test area was approximately 45' x 20' in size. Based on an initial sample, primary explosives of concern (and associated baseline levels of contamination) were: TNT (383 mg/kg), RDX (180 mg/kg) and HMX (15 mg/kg). Discrete sampling (EPA Method 8330A) was utilized at target hot spots with visible evidence of explosive compounds on soil surface. The average concentration of primary explosive compounds were TNT (3,347 mg/kg), RDX (5,977 mg/kg), and HMX (640 mg/kg). Other explosive compounds were detected in the soils at much lower concentrations.

Solution

MuniRem Environmental conducted a baseline characterization of the contaminated soil to determine the type and concentration of explosives present. MuniRem activators and main reagent were tilled into the explosive contaminated soil. Water was then added to initiate the rapid explosive degradation reaction by MuniRem reagent. The efficacy of the treatment was monitored 24 hours following application and was confirmed two weeks thereafter.

Result

Analysis of the treated soil samples confirmed that MuniRem achieved the cleanup goal in the 24 hours after application, which was reconfirmed two weeks later. Further analysis confirmed that the cleanup goal was achieved in two weeks for the hot spot area that had showed visible chunks of explosives. MuniRem was effective in the remediation of low and high concentrations of explosives in soil. Blackened soil areas following MuniRem treatment characterized the effectiveness of MuniRem to instantly neutralize the chunks of explosives in soils within the hot spot areas. The effectiveness of MuniRem was independently validated by a certified chemical data validator.

Engagement details

Client

Department of the Army, U.S. Army Corps of Engineers

Site

Ravenna Army Ammunition Plant ("AAP"), Ohio

Task

In-situ Rapid Chemical Degradation of Munitions Constituents in Soil by MuniRem

Date

October 2009

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MuniRem activators and main reagent are easily applied...



...before being tilled into the explosive contaminated soil



Blackened soil characterizes the neutralization of chunks of explosives in the hotspot areas

In-Situ Bioremediation of Perchlorate and Explosives

Situation

From 2002 to 2007, MuniRem Environmental was contracted by the Army Operation Support Command to demonstrate and apply SAMNAS to remediate perchlorate and co-contaminants, such as high explosives in soil at an open burn open detonation (OBOD) site, Longhorn AAP. This site's underlying soil had been contaminated by byproducts of incomplete combustion/detonation of ammunition or energetic materials. The application of SAMNAS at Longhorn AAP in 2002 was the first field application of an in-situ bioremediation process to remediate perchlorate-contaminated soil at depth (i.e. in vadose zone source area).

Solution

MuniRem Environmental characterized the extent of soil contamination prior to conducting its treatment by SAMNAS. MuniRem Environmental remediation process included tilling bacteria-rich nutrients into the contaminated top soil to stimulate the degradation of the contaminants of concern; the SAMNAS solution were then progressively infiltrated through the ground. Traditionally expensive dig-and-treat methods are therefore not necessary. The monitoring of contamination levels was performed bi-monthly and confirmed the progressive decrease of contaminants of concern in the treated surface and deeper soils.

Result

The test carried out in 2002 confirms that SAMNAS is effective for in-situ bioremediation of perchlorate in soil. SAMNAS successfully met the site's objectives for remediation of perchlorate and explosives within a 10 to 12-month period. The replanting of indigenous vegetation on site

Engagement details

Client
Department of the Army, U.S. Army Corps of Engineers

Site
Longhorn Army Ammunition Plant (AAP) in Karnack, Texas

Task
In-Situ Bioremediation of Perchlorate and Explosives by SAMNAS

Date
September 2002 to June 2004

was not only possible after treatment, but also contributed to "cleaning up" any residual contamination and to improve the site's environment. SAMNAS has been approved for a further two performance based contracts by the US Department of the Army.



Irrigation system at work –treated site covered in hay

Site after treatment and revegetation

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MuniRem - Faster, Better, Safer, Cheaper

	Traditional Remediation Methods	MuniRem Environmental MuniRem
Treatment Time	<ul style="list-style-type: none"> • Weeks to years • Dig & haul - slow and not scalable 	<ul style="list-style-type: none"> • Hours to days • Simple setup and application
Treatment Effectiveness	<ul style="list-style-type: none"> • Dig & haul does not remediate hazardous chemicals; only relocates • Incineration & OBOD emit toxic gases and greenhouse gases 	<ul style="list-style-type: none"> • Rapid, in-situ or ex-situ; 100% ecofriendly and biodegradable • Generates innocuous by-product
Application Safety	<ul style="list-style-type: none"> • Combustion - high pollution • Alkaline hydrolysis - hazardous pH conditions • Careful handling & monitoring required 	<ul style="list-style-type: none"> • Safe ambient room temperature & pH process • Little danger to the user or community
Cost / Capital Investment	<ul style="list-style-type: none"> • High upfront plant / equipment costs • High post-treatment costs • Digging / transportation costs • By-product remediation costs 	<ul style="list-style-type: none"> • Flexible and scalable with a "pay-asyou-go" model • NO material upfront costs • Typically 30-50% less than traditional methods

Explosive contaminated munitions casing, soil and equipment



Picric Crystals (yellow)
Rusts (bright orange)



Picric acid (bright yellow)



Picric Crystals (bright yellow)

After MuniRem treatment



No visible traces of energetics



2 weeks after MuniRem



No re-crystallization of picric acid

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RAPID CHEMICAL NEUTRALIZATION OF EXPLOSIVES IN MULTIPLE MEDIA

MuniRem

MuniRem is a chemical formulation invented in the US by MuniRem Environmental's founder over a ten-year period of laboratory and field testing:

- Proven, rapid, in-situ or ex-situ chemical solution for munitions constituents (organic pollutants, heavy & toxic metals, pesticides) in soils and groundwater
- Proprietary, patented and exclusively licensed chemical formulation that can meet and exceed the most stringent remediation

MuniRem consists of selected bulk reductants that:

- Degrades PCBs and explosives into nitrogen gas, formate and non-hazardous trace elements
- Reacts with toxic and heavy metals into insoluble metal sulfides

MuniRem formulation and application is tailored to each site to ensure optimum performance and desired results:

- It can be applied as a solid or aqueous solution to achieve optimal and desirable results
- **Contaminated soils treatment** involves mixing MuniRem into the soils and adding water to achieve in-situ or ex-situ remediation.
- **Groundwater remediation** involves injection of the MuniRem solution into the site groundwater to instantly degrade the dissolved contaminants and create permeable reactive aquifer solids for long-term treatment of the plume.
- **Decontamination applications** involve spraying the MuniRem solution on building walls, large equipment and scrap metals (including bombs shells, bomb components, projectiles); and soaking small sized equipment in MuniRem baths.
- **Range Management and Remediation** involves applying MuniRem-BC (Biochar reinforced with MuniRem reagent). The sorption of MCs by biochar and proven degradation of bulk explosives and MCs by MuniRem reagent are realized in range soils over many months from a single application.

MuniRem was voted a 2010 Better World Technology by the Association of University Technology Managers.

Proven Capabilities & Field Success

MuniRem has successfully neutralized recovered munitions fillers (bulk explosives) and decontaminated explosive residues on bomb casings, demilitarization equipment, building walls, open burn open detonation (OBOD) ash and contaminated soils including:

i. US Army:

Multiple 10-lbs batches of explosives (Composition D) recovered from Navy projectiles neutralized within 20 minutes

ii. US DoD Demilitarization Facilities:

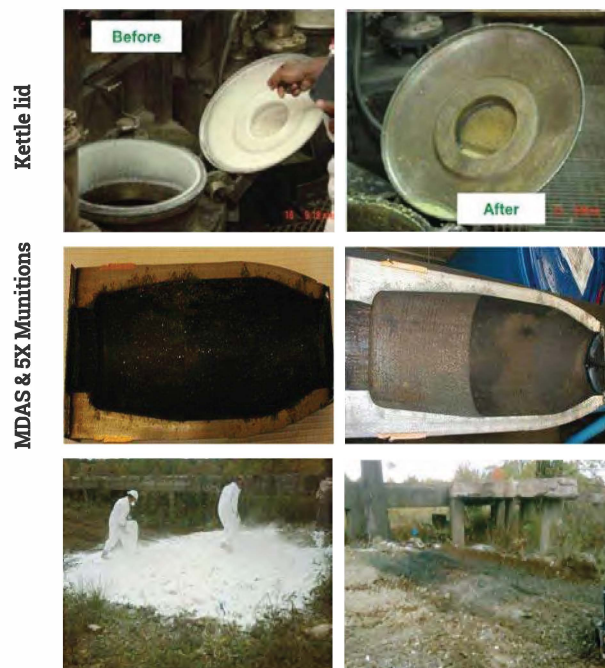
Contaminated equipment (kettles, autoclaves, & conveyor belts), building walls, gaskets, bomb casings, OBOD ash, pink water & Granular Activated Carbon (GAC) were rapidly decontaminated to nondetect levels (US DoD level 5x decontamination) with no hazardous by-product and discharge to clean up.

iii. Ravenna Army Ammunitions Plant:

In-situ treatment of field soils with high concentrations (>20%) of TNT, RDX and HMX and achieved cleanup goal for energetics in less than 2 weeks.

IV. Active US DoD Munitions Manufacturing Plant:

The MuniRem solution is applied to neutralize energetics and decontaminate building fixtures, removing explosive hazard before maintenance and renovation work by construction contractors.



MuniRem onsite remediation on contaminated soil

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RAPID CHEMICAL STABILIZATION OF METALS IN MULTIPLE MEDIA

MuniRem

- A proprietary, patented and exclusively licensed chemical formulation
- Proven to meet and exceed the most stringent clean-up goals faster, better, safer and cheaper
- Flexible enough to be used on various media
- Every formulation and application is tailored to each site to ensure optimal performance and desired results
- MuniRem consists of selected bulk reductants that:
 - Binds with toxic and heavy metals forming insoluble metal sulfides
 - Proven field and laboratory success with reactive metals commonly found at contaminated sites
 - Metals treated by include: *aluminum, arsenic, barium, beryllium, cadmium, chromium, lead, mercury, iron, selenium, uranium, etc.*

Proven Capabilities on Treatment of Heavy Metals

Below display MuniRem Environmental TCLP successful field results from:



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MuniRem Reagent is packaged in UN rated pails and drums, available in 5lb (2.3kg), 45lb (20kg) and 220lb (100kg) sizes. It can be shipped by land, sea and air. Contact info@munirem.com for further information.



ABOUT R.A. McCLURE INC. (RAM)

RAM is an international blast engineering and consulting firm that focuses on improving productivity and safety through blast optimization, advanced technical and turn-key remediation services.

- Ecofriendly and Rapid Neutralization of Explosives
- Field Explosive Detection Kits
- Portable X-Ray Systems
- Remote Video and Close Circuit TV
- High speed cameras 1,000 fps
- Borehole Cameras (1500' depth)
- Lightning Prediction & Detection Systems
- Blast Mitigation Technology
- Explosive Containment Trailers

RAM in partnership with **MuniRem Environmental LLC** provides **MuniRem®** as a cost effective green solution for the remediation of soil and groundwater, buildings and equipment that are contaminated with explosives residues. **RAM** distributes **MuniRem®** through-out North & South America, Africa, Australia and Europe.

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